(NASA-CR-168791) MEAN VELOCITIES AND REYNOLDS STRESSES IN A JUNCTURE FLOW Semiannual Status Report, period ending 31 Mar. 1982 (Georgia Inst. of Tech.) 11 p HC A02/MF A01 CSCL 01A G3/02

N82-22208

Unclas 09605

MEAN VELOCITIES AND REYNOLDS STRESSES IN A JUNCTURE FLOW

Semi-Annual
Status Report
to
March 31, 1982

NASA GRANT NAG1-40 (Supp. No. 3)

H. McMahon, J. Hubbartt, L. Kubendran

School of Aerospace Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332

INTRODUCTION

The first major task under this Grant was the measurement of three mean velocity components and six Reynolds stresses at two streamwise station in a juncture flow (fig. 1) using hot-wire anemometer techniques. This task has been completed, and a draft of the Final Report has been forwarded to the NASA Technical Officer for review.

The task to be performed under the present Grant Supplement is to extend these same measurements to a region near the body leading edge (fig. 2).

STATUS

In order to be able to move the instrumented segment containing the hot-wire measurement probes (fig. 1) to the new upstream stations, it was necessary to design and construct movable segments of the proper dimensions so as to give the required locations of the streamwise (x) measurements stations. It also was necessary to modify the upstream legs of the structure which supports the flat plate since there was interference between these legs and the instrumented slide which moves in the transverse (z) direction. These modifications have been completed.

It will be recalled that the flat plate and the boundary layer development section are located 216 mm (8.5 in.) above the wind tunnel floor at the tunnel exit (fig. 3). This location is dictated by the fact that the floor boundary layer at the exit plane of the tunnel is very thick because of the long test section. If this boundary layer were used for the juncture flow, the ratio of body thickness to boundary layer thickness would be too small to represent a practical case. The body thickness is limited, since as it increases the flow field of interest is displaced outward and there is risk of interaction with the edges of the free jet. Thus, a new boundary layer of appropriate thickness is developed on the flat plate for these experiments. At the furthest upstream measuring station x = - 152 mm (-6.0 in), the probe actuator, which is hung from the bottom of the plate, is at the exit plane of the tunnel. As a result, there is some blockage of the flow area between the bottom of the boundary layer development section and the floor of the wind tunnel because of the presence of the actuator guide rods and lead screw in the exit plane. Such blockage could lead to spillage of the flow over the top of the boundary layer development section, which would alter the turbulent boundary layer on the measurement surface of the flat plate. In order to check for possible spillage, a

wooden mock-up of the actuator was built and installed at the furthest upstream measurement station. A surface oil film flow visualization was carried out near the leading edge of the boundary layer development section. No evidence of spillage was noted.

Just before the planned beginning of the upstream measurements under this Grant Supplement, a problem was encountered with the slant hot wire (fig. 4). This problem was detected as a lack of repeatability, primarily in the measurement of the vertical component of mean veloicty U_y. In particular, the final measurements of U_y in the juncture at 165 mm (6.5 in.) did not check those taken much earilier at that same station. The last data showed an increase in the pitch angle of the flow in the outer half of the viscous layer of about 1.5° when compared with the earlier data. This lack of repeatability was considered to be unacceptable, particularly when it could not be traced to anything obvious but rather suggested that something had changed during the course of the juncture measurements.

Considerable time and effort was expended in determining the cause of this problem. The hot-wire probe and the model alignment were carefully checked. The wind tunnel used here is of the open return type. It was suspected that some dirt might have built up on the screens of the wind tunnel, which would lead to non-uniformity in the freestream flow. On this premise the screens were cleaned, three were replaced, and the entire wind tunnel area was cleaned as well. During all of this, check measurements of U_y showed no change.

The slant wire probe had been checked by eye, by using an optical comparator, and, during operation, by using a transit. No anomolies were discovered. Referring to figure 3, the two needles which support the wire pass through two small clearance holes in a plastic surface plug and pass in and out through these holes as the probe moves vertically in changing the value of the vertical (y) ordinate during profile surveys. During one of the many diagnostic tests with the probe, a very small change (0.01 ohm) in cold resistance was detected as the needles moved in the y direction. The surface plug (fig. 4) is a press fit in the probe and is held by three set-screws. At some time during the juncture surveys the surface plug must have rotated slightly as the probe was being stepped in rotation. As a result, one needle touched the side of its clearance hole and this caused the needle to bend slightly as it moved in the y direction. This bending, in turn, put a different tension on the wire as y was increased and this slight change in tension caused a change in wire resistance. This resistance change showed up as a

velocity component change when the slant wire was used in two orientations to find U_y.

The surface plug used in the orginal design, when this problem arose, was made in one piece. It could not be removed because it would not slide over the offset needle of the slant wire (fig. 4). Accordingly, the plug was raised and held in a jig while it was cut away from the needles. A new split surface plug, shown in figure 4, was made with the clearance holes slightly enlarged, the new unit was assembled, and a new hot-wire was installed. Measurements of U_y made after this modification repeated those made much earlier, hence there is confidence in the opinion that this differential tension on the wire was indeed the cause of the problem.

Despite the fact that the tension problem was most critical in determing U_y, (its effect on the other components measured with the slant wire within the experimental scatter) it was decided to repeat all of the slant wire measurements at the two measuring stations in the juncture in order to have a high confidence level in the data for the Final Report which has just been completed.

The time consumed in finding and correcting the problem with the slant wire, and in repeating some of the measurements in the juncture, has resulted in the upstream measurements being behind schedule. However, data-taking has begun, and measurements of the local yaw angle, θ , at $x = 76$ mm (3.0 in.) downstream of the leading edge are shown in figures 5 and 6. These are representative data; surveys were made at 15 z-stations over a range of distance from the body surface of from 10 mm (0.40 in.) to 178 mm (7.0 in.). Comparable measurements further downstream in the juncture at $x = 165$ mm (6.5 in.) are shown in figure 7.

Inspection of figures 5, 6, and 7 indicates that the skewing of the boundary layer near the plate surface ($y \doteq 0$) is much larger at the upstream station. The maximum variation in local mean flow direction at $x \doteq 76$ mm (3.0 in.) is about 12° compared with 9° at $x = 165$ mm (6.5 in.)

Data acquisition and analysis are continuing. In order to compensate for the time lost at the beginning of the Grant renewal period, an additional M.S. Graduate Research Assistant has been assigned to this work, at no additional cost to the Grant. This student will aid in running the wind tunnel and in taking data, and it is hoped that this additional help will allow the originally projected schedule to be attained.

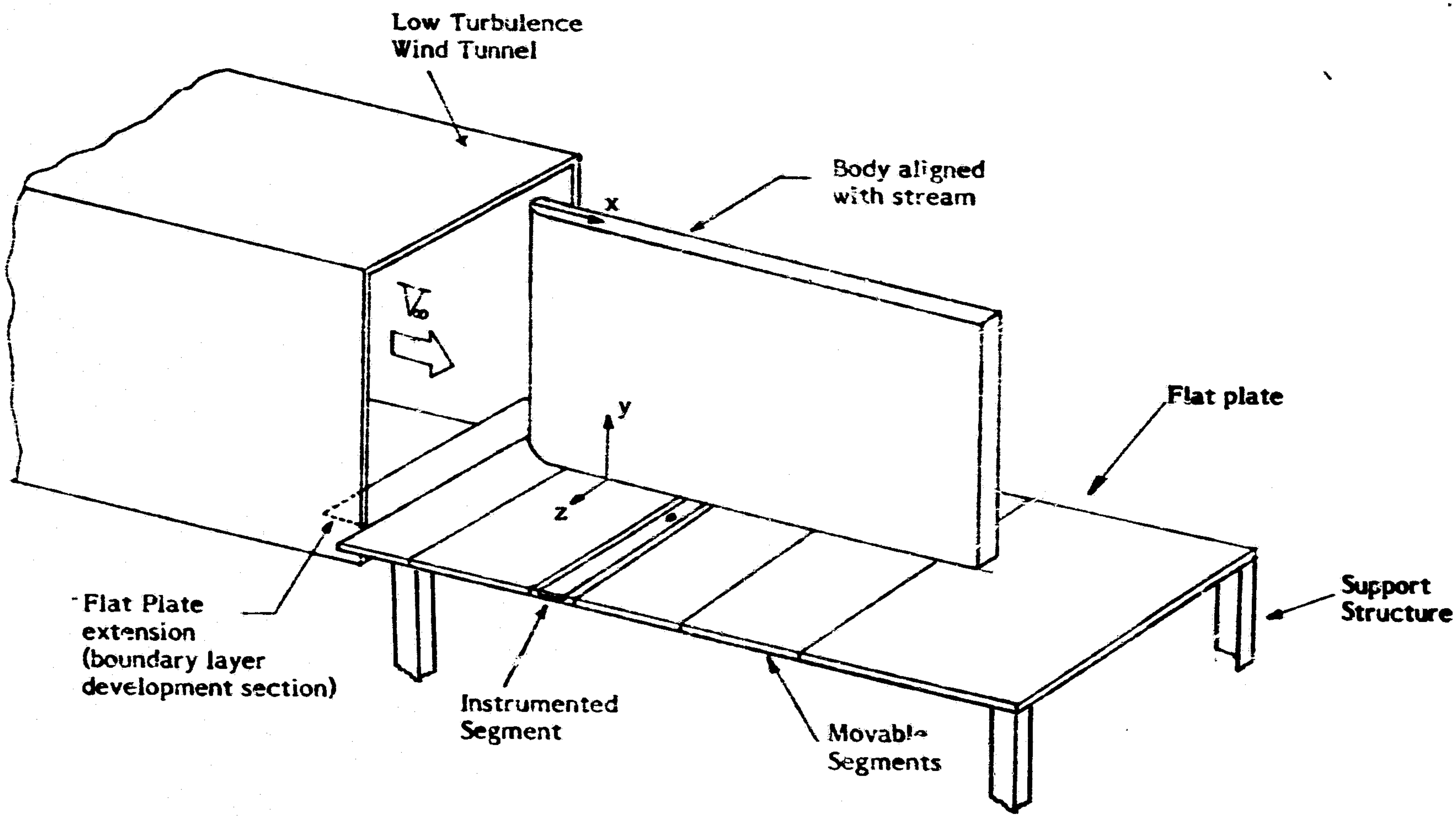


Figure 1. - Flat Plate and **body** at the exit of the wind tunnel.

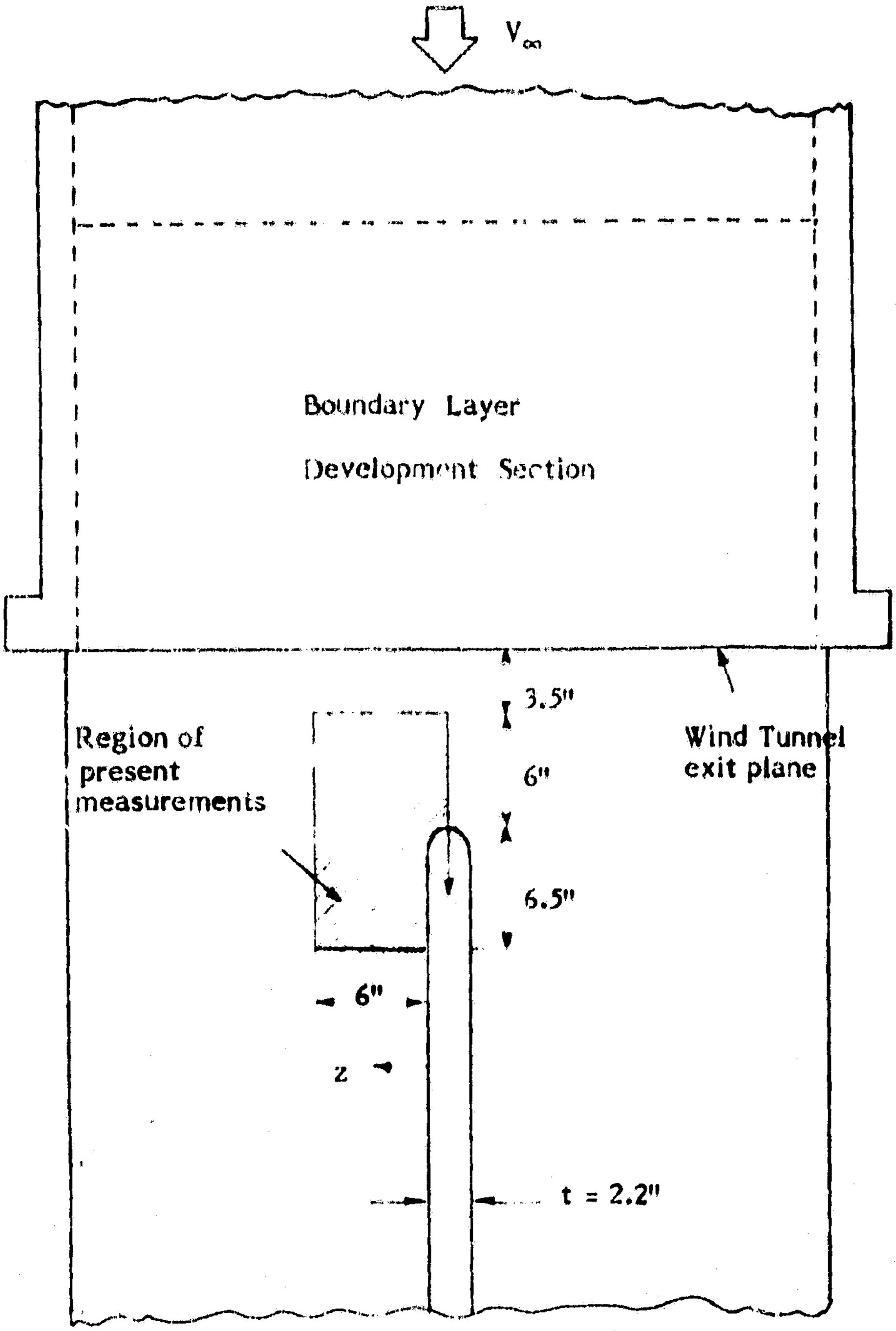


Figure 2. - Proposed Measurement Region on Flat Plate (Plan View).

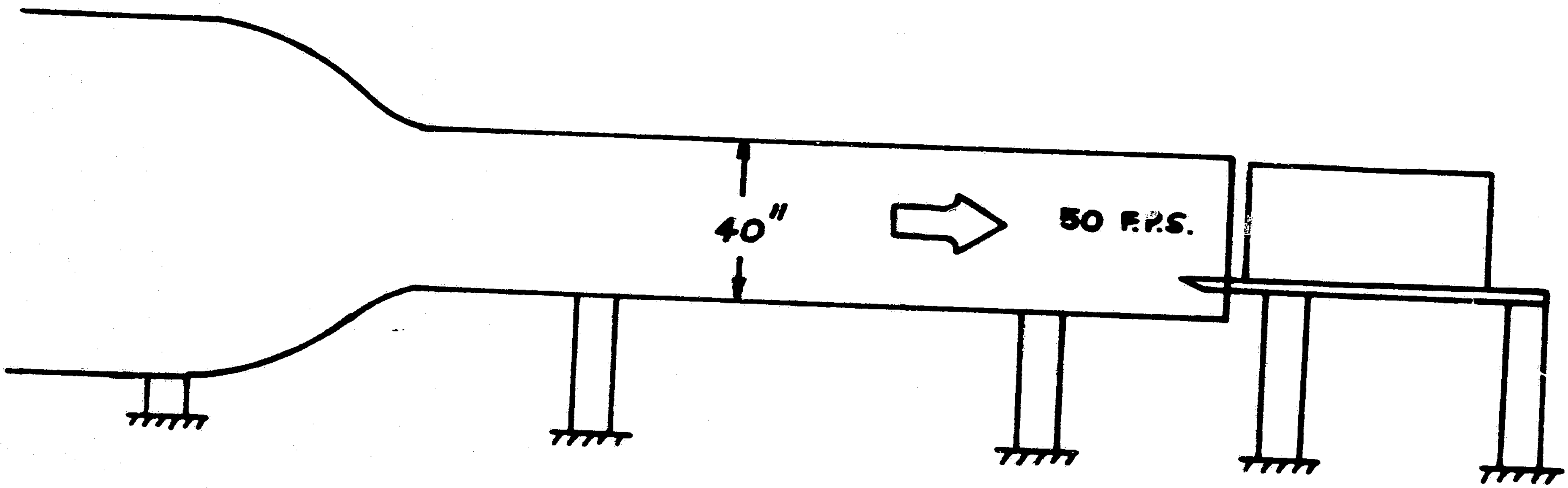


Figure 3. - Wind tunnel and the experimental set-up (side view)

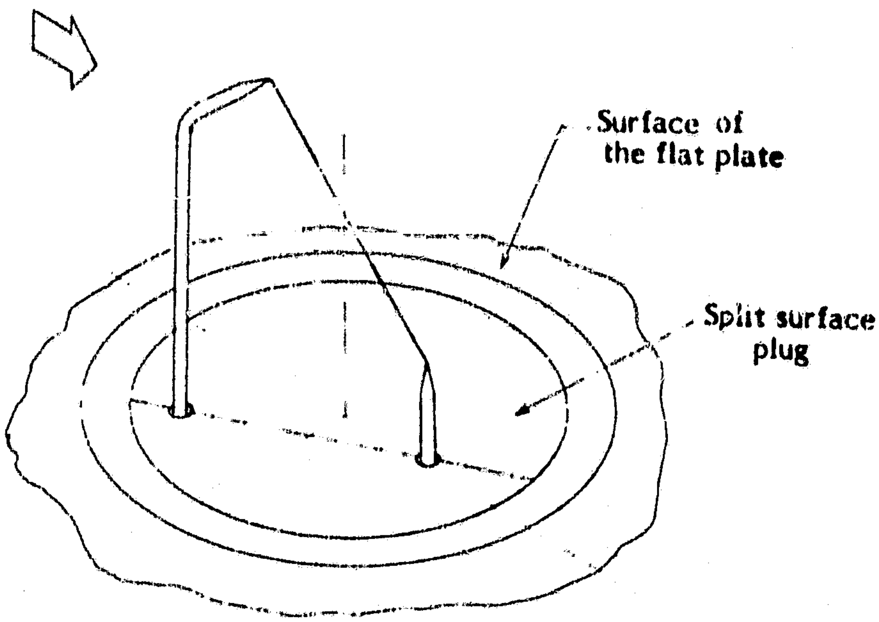


Figure 4. - Details of slant wire.

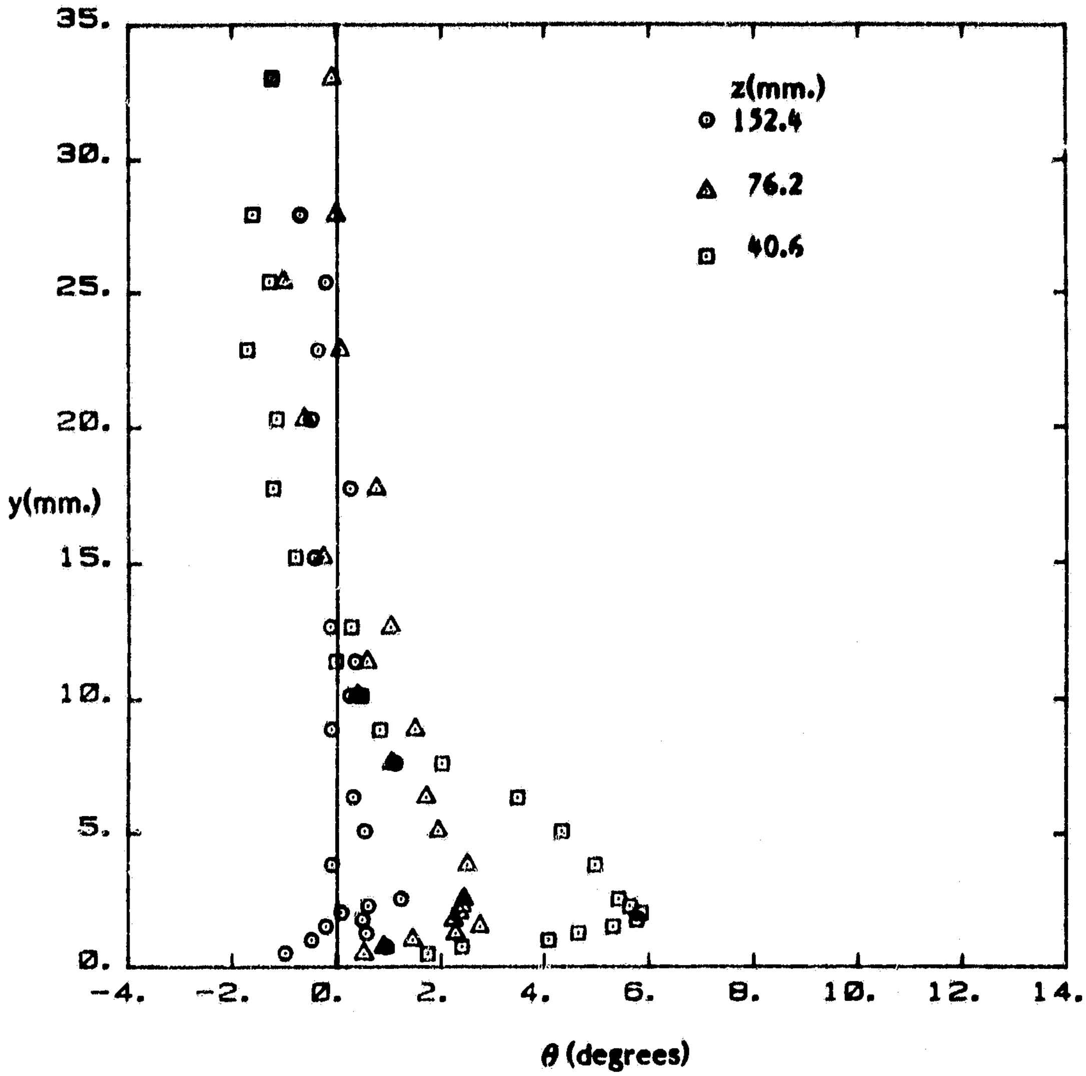


Figure 5. - Variation of local mean flow direction in the juncture (x = 76 mm.)

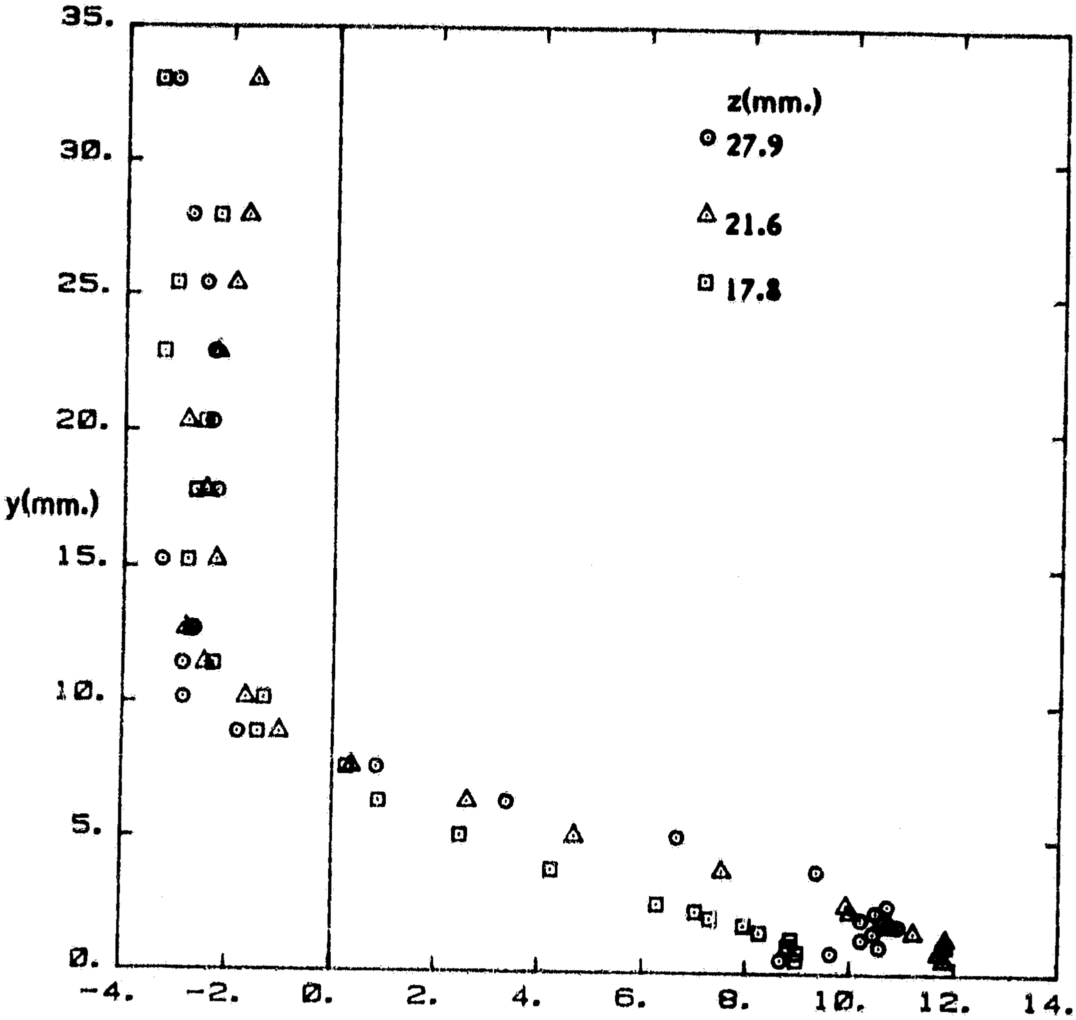
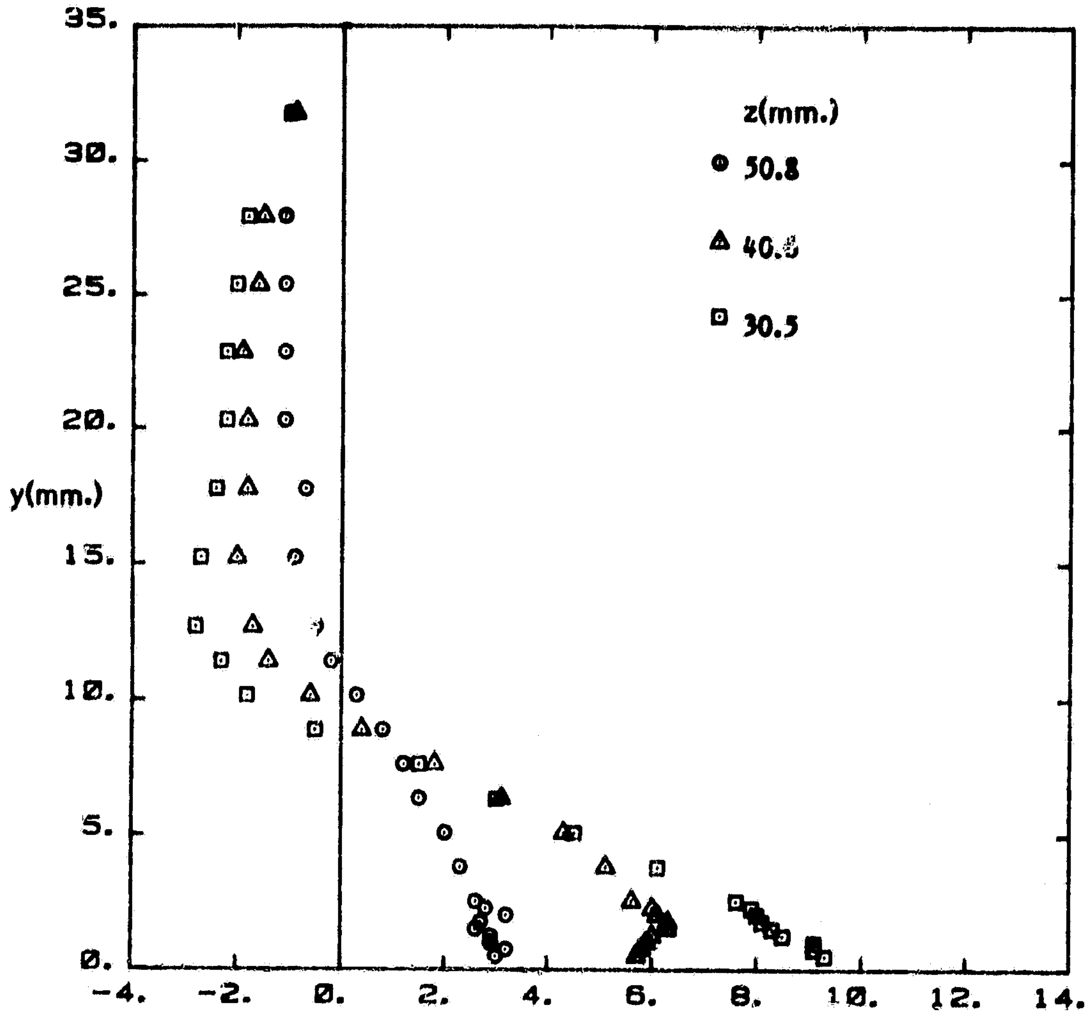


Figure 6. - Variation of local mean flow direction in the juncture (x = 76 mm.)



θ (degrees)

Figure 7. - Variation of local mean flow direction in the juncture (x = 165 mm.)